ACCOUNTING FOR RISK IN THE SELECTION AND USE OF SIRES AND SONS IN PROGENY-TESTING PROGRAMS

J. F. Taylor, P. F. Parnell, and K. Hammond

Animal Genetics and Breeding Unit[1]
University of New England, Armidale, New South Wales 2351

The important contribution which the sire-to-breed-son pathway makes to total genetic change in breeding programs based on progeny-testing is well recognised. To optimise progress on this pathway AI bull-breeding studs must decide which bulls to select to sire sons and how many sons each bull should sire for testing.

In the absence of bias, estimates of genetic merit, such as Estimated Breeding Values (EBVs) or Predicted Differences (PDs), calculated using Best Linear Unbiased Prediction (BLUP) methods, will have minimum Standard Errors of Prediction (SEPs) and an equal probability of either over-or under-estimating a sire's true genetic merit. Hence, to maximise long-term genetic gain in a population only the highest-ranking sires on EBV for the traits of interest should be selected to breed sons. However, where only a very few sires are to be selected, chance – or equivalently genetic drift – may have important consequences on the short-term outcome of a breeding program. In such circumstances the risk of short-term losses can be minimised by also considering the magnitude of the SEPs or reliabilities of the EBVs of each candidate for selection. An evaluation (EBV) having a high SEP (low reliability of repeatability or accuracy) has a greater potential to fall (or increase) as more information becomes available and the risk of obtaining short-term losses (or gains) becomes greater.

Schneeberger *et al.* (1981, 1982) considered the problem of optimising dairymen's semen purchasing decisions to maximise future herd profitability, given an acceptable level of risk governing yearly genetic drift. They used 'utility' functions to quantify the subjective weighting ot expected income (Average Predicted Differences of selected sires) to variance of expected income (a function of the repeatabilities associated with the PDs) made by individual decision-makers having either an aversion or willingness to take risk. Quadratic programming was employed to determine the optimal usage of available semen to maximise 'utility' for a given level of risk acceptance. Taylor (1983) pointed out that AI studs face exactly the same problem when deciding which bulls to select to sire sons and how many sons of each bull should enter the stud for testing. He detailed the methodology required to consider jointly, differences in EBVs and SEPs to differentiate optimally between potential sires to breed sons for a range of levels of risk acceptance.

EXAMPLE

We illustrate the application of this methodology by considering the following problem of optimally selecting proportions of sons from a population of ten potential sires to breed sons. Table 1 lists the EBV and SEP expressed in units of dollar value and limits (caused by management or breeding program design) on the proportion of sons required, for each potential sire.

Using this information, the proportion of sons required from each of these sires to maximise genetic trend (expected income) was computed for a range of acceptable risks, changing emphasis on variance of income. These optimum proportions, rounded to the second decimal place, are given in Table 2.

[1] A joint unit of the NSW Department of Agriculture and the University of New England.

Table 1: Potential sires to breed sons in the example

Sire	EBV ($)	SEP ($)	Limits on Proportion of Sons	
			Lower	Upper
A	204	43	.10	.40
B	191	10	.00	.20
C	184	39	.00	.30
D	169	45	.00	.40
E	165	47	.10	.40
F	161	9	.00	.20
G	151	48	.00	.40
H	151	39	.00	.30
I	133	4	.00	.10
J	128	43	.00	.40

Table 2: Optimum proportions of sons, expected incomes, and variances of incomes for a range of risk weightings

Sire	Weighting for Risk				
	.00	−.04	−.08	−.10	−.30
A	.40	.30	.20	.18	.10
B	.20	.20	.20	.20	.20
C	.30	.20	.17	.16	.10
D	.00	.06	.08	.08	.06
E	.10	.10	.10	.10	.10
F	.00	.15	.20	.20	.20
G	.00	.00	.02	.03	.04
H	.00	.00	.03	.05	.06
I	.00	.00	.00	.00	.10
J	.00	.00	.00	.00	.03
Expected Income	191.5	185.16	180.13	178.7	169.6
Variance of Income	458.8	256.6	163.4	147.5	83.2

A risk weighting factor of zero corresponds to maximising income by selecting only top sires on EBV, ignoring SEPs. As this weighting becomes increasingly negative, emphasis is placed upon minimising the variance of income rather than maximising expected income. This is achieved by increasing the proportion of sons assigned to bulls with low SEPs that have lower EBVs than bulls with high SEPs. Hence long-term genetic progress is sacrificed for a reduction in genetic drift. The method permits the monitoring of this trade-off between progress and drift. It is significant that for negative risk weightings close to zero, little genetic progress is lost while appreciable reductions in drift may be obtained.

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